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Vertical Landing Aids Design and Test Tool Utilizing Microsoft Flight Simulator™ Visualization and Virtual Reality

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Abstract

Stottler Henke is developing a test and design tool utilizing Microsoft Flight Simulator that can be used to support vertical takeoff and landing (VTOL)/rotorcraft ship VLA design and testing at the test team member's work area. This allows designers and testers to fly shipboard approaches in specific aircraft, to the deck of a specific ship class, with a realistic view during day and night operations as well as under a variety of weather conditions, while providing an easy method of adjusting ship VLA components and environment lighting. The visuals can be screen based or a head mounted display can be used with head tracking to allow a virtual reality environment.

Key Words

Visualization, Synthetic Environments, Visual Landing Aids (VLA), VTOL, Design and Testing

1. Introduction

Visual landing aids (VLAs) provide necessary support to the landing of aircraft on ships, see Figure 1. For existing ship classes with fixed lighting systems, the ability to differentially adjust the intensity of drop lights, glide slope indicators, flood lights, and deck status lighting provides focus on different pilot cues during shipboard landing in a wide variety of meteorological conditions [1]. The use of color, and the quality of color (chromaticity) [2], is also used to provide focus on different approach and landing cues in varying meteorological conditions. The drive is to allow for a wider envelope of operations for aircraft from ships. That is, it is desired to be able to safely operate VTOL aircraft in higher sea states and lower visibility conditions than is allowed today.

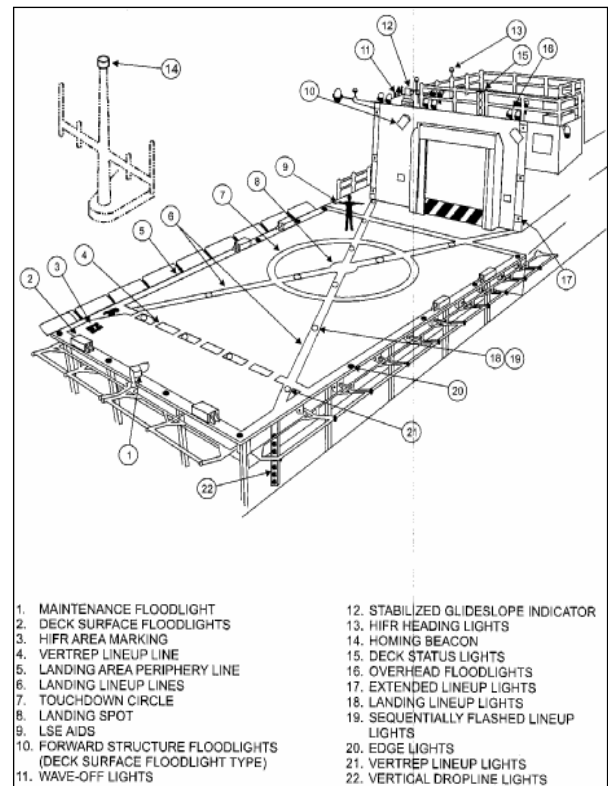


Figure 1. Flight Deck with Visual Landing Aids

The design of safe and effective VLAs requires that the pilot be presented with cues that are conspicuous and easily comprehensible during the approach [3]. These cues must be of a nature that is consistent in different circumstances, and requires little training for effective use [4]. The goal of any shipboard VLA system is to, as much as possible; enable pilots in low visibility situations to follow a similar approach path and landing sequence afforded by day, Visual Meteorological Conditions (VMC) cueing.

To be able to provide VLA test team members with the greatest access to the analytic test tool it would be advantageous if it was available on the nearly ubiquitous Windows personal computer (PC). This would allow for the greatest access to the tool, for PCs are usually shared

resources at training locations and anywhere a PC of sufficient capabilities to host the tool was available, the tool itself could be made available. In addition, the tool could optionally be hosted on private PCs, so VLA test team members could design and test at their personally owned computer. In addition, since many computers are now laptops the tool could be easily transportable when installed on a laptop and brought to Dynamic Interface trials.

To summarize, in order to improve decision-making in this complex domain in an affordable manner, design and testing in simulated situations is critical. Therefore, the immediate challenge is to provide test team members an test and design tool on a PC at their workstation, allowing them to fly shipboard approaches in specific aircraft, to the deck of a specific ship class, with a realistic view in day and night operations and under a variety of weather conditions, while providing an easy method of adjusting ship VLA components and environment lighting.

2. Overview of Solution

We are developing VERTICAL (VLA Experimental Resource for Testing Innovative Configurations And Lightings), a test and design tool that can be used to support vertical takeoff and landing (VTOL)/rotorcraft ship VLA design and testing at the test team members' work area. This is being accomplished by utilizing MS Flight Simulator, FSUIPC and Java.

The test team members' high-level interaction with VERTICAL is as shown in Figure 2 above the dotted line. Test team members are presented with a fully navigable, three-dimensional environment (the *Visualization Environment*) provided by MS Flight Simulator containing the ship being targeted for VLA design. The environment may include other aircraft flying or on the ship, essentially the environment is able to replicate whatever should be simulated to duplicate realistic conditions.

The *VLA Modification GUI*, developed as a separate application developed in Java provides an intuitive interface for modifying the VLA components. In the future, test team member and pilot feedback will be collected in real-time by the *VLA Setup & Feedback GUI*, a mostly non-visual module which records typed or spoken comments, and provides facilities to associate those comments with discrete, user-defined states in the VLA design. This module will also provide a simple, non-visually-invasive tool for saving and reloading "checkpoints" in the test process, allowing new VLA layout ideas to be implemented and reverted with minimal hassle.

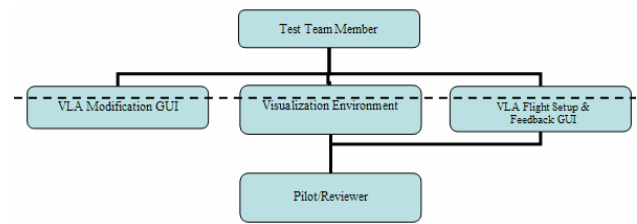


Figure 2. VLA Test Team Member High-Level Interactions

The area below the dotted line in Figure 2 represents the pilot / reviewer's high level interaction with the system. Pilots testing VLA designs will be provided with the same three-dimensional environment as testers. Pilots / reviewers will have access to the same VLA Setup & Feedback Interface as their test team member counterparts, though their feedback (primarily spoken, but with facilities for written comments) will be recorded in a separate, time-matched stream for later review and comparison with those of the test team member.

To date we have developed a prototype of the system as described below.

3. VERTICAL Prototype Description

Our prototype application combines an interactive graphical user interface with a custom LHD ship and aircraft models which are controlled and rendered by Microsoft Flight Simulator 2004. By utilizing Microsoft's off-the-shelf simulator package, we are able to render extremely detailed three-dimensional graphics (with accurate physics) that simulates visual scene properties relevant for simulating low-altitude flight [5] at low cost, and with significantly reduced development time compared to custom tools. Figure 3 shows modules or our overall design, and the shaded circles represent those demonstrated in the prototype.

A requirement for analysis is ship motion, we have developed a destroyer previously that had the ability to pitch and roll, as well as have a forward motion, this capability has not yet been ported to the LHD ship. Of course, the relative motion of the ship has a significant influence on many aspects of the design of the complete VLA configuration, so realistic motion must be provided before any design can be concluded.

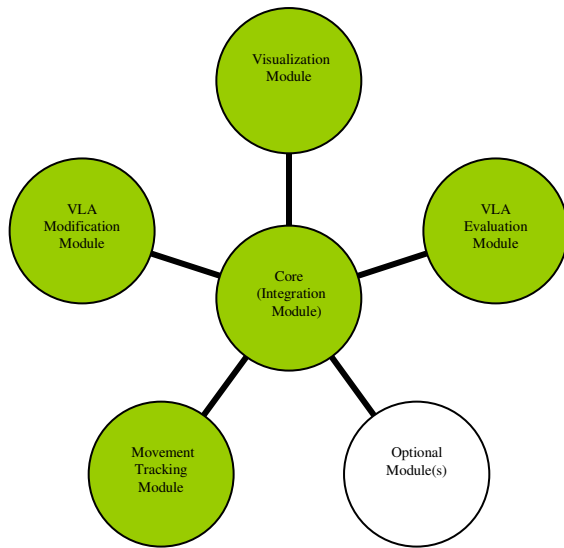


Figure 3. Shaded Modules Demonstrated in Prototype

The following subsections describe the prototype and its modules.

3.1 Visualization Module

The visualization module utilizes Microsoft Flight Simulator 2004 (“MS FS”) for the visualization engine and the LHD was developed utilizing COTS tools (e.g., gmax®, see www.discreet.com/products/gmax) and proprietary tools which can create models in MS FS format and OpenFlight format.

The ship is dimensionally accurate, richly detailed, and includes a large number of dynamically-modifiable VLA lights. This extremely high level of detail (see Figure 4, Figure 5 and Figure 6) provides lighting designers and test pilots with a far more accurate representation of the “final product”, reducing the simulator-induced error that has occurred with less detailed models.

The visualization module communicates with the core (integration module) via an external system interface (ESI) written in a product called FSUIPC. The lights on the ship can be controlled via the VLA modification module further discussed below.



Figure 4. Bird's-eye view of LHD amphibious assault ship



Figure 5. Close-up 1 demonstrating level of detail of LHD model



Figure 6. Close-up 2 demonstrating level of detail of LHD model

Weather conditions and the day/night settings are handled in MS FS and allow the setting of any weather condition desired or the current conditions can be downloaded from the internet for any location. For example, Figure 7 shows the LHD in a foggy dusk condition with many of the LHD's lights on.



Figure 7. Foggy Conditions at Dusk

A beneficial aspect of the MS FS is *slew mode*. This allows the user to easily change the location of the aircraft approaching the ship without having to actually fly. By using simple keyboard commands one can move forward, back, left, right, up, down, etc. Of course, one can fly also using various joysticks, or add more realistic flight controls.

3.2 Field-of-View

The external field-of-view is available with multiple perspectives in the prototype, including:

- From cockpit: not occluded
- From cockpit: showing cockpit
- From spot outside of aircraft, showing aircraft.

The field-of-view can be easily changed while flying. The following figures utilize a Harrier on approach. Figure 8 shows the Harrier on approach showing the view from the cockpit, with the view unobstructed by the cockpit. Figure 9 shows the Harrier on approach from a “spot plane” location, this spot plane can be anywhere with any zoom level; note also in this figure that the weather conditions have been changed and smoke is shown, the smoke is dynamic and will be effected by the conditions, e.g., the ship speed and wind direction. Figure 10 shows the Harrier on approach showing the view from the cockpit, with the cockpit shown; it is also easy for pilot to move their head in the cockpit, that is, one can move forward so less of the cockpit is seen or move one's head from side-to-side to see in directions other than forward. This can be done via keyboard commands, the “hat” on many joysticks and simply by moving ones head if wearing a head tracking device. See the Movement Tracking Module section for more information.

Note also that any view from the deck or anywhere else on the ship can be obtained easily and saved for quick recall if desired.

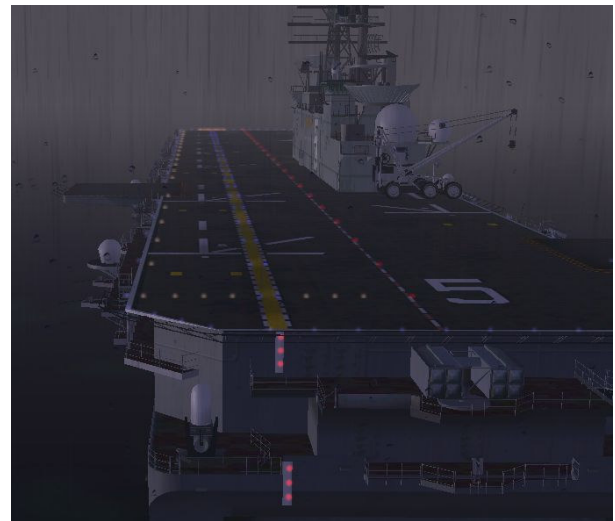


Figure 8. Field-of-View: From Cockpit: Not Occluded



Figure 9. Field-of-View: From any Spot Outside of Aircraft



Figure 10. Field-of-View: From Cockpit: Showing Cockpit

3.3 Aircraft

Microsoft Flight Simulator has most Navy and Marine aircraft available for it. One of the few that were not already available commercially was the new MH-60S and MH-60R helicopters. Fortunately, these have been developed by Stottler Henke for one of our other projects [6] so it is available in VERTICAL. Figure 11 shows an example aircraft, the V-22 Osprey.



Figure 11. V-22 Osprey

3.4 VLA Modification Module

A graphical user interface, written in Java Swing, allows individual customization of every modifiable light on the LHD ship (see Figure 12, and Figure 13). State (on/off), color, and intensity can be interactively modified with real-time feedback from the ship model. The large number of controllable lights is broken into subgroups by function, with each subgroup receiving its own tab on the main GUI panel to prevent the interface from becoming overwhelming.

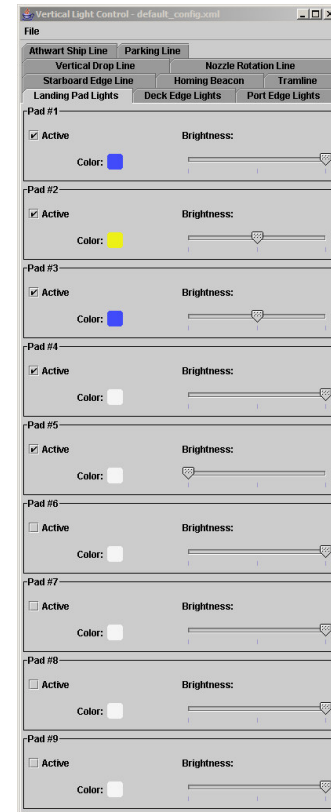


Figure 12. Light Controls Main Interface

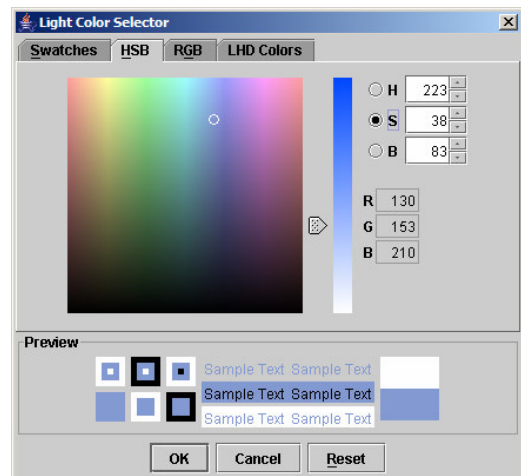


Figure 13. Light Color Selector: HSB Option

Using this tool, test team members are able to get a realistic, “in-flight” view of lighting arrangements from a number of relevant aircraft, and in all manner of weather conditions. Without leaving the application, lighting parameters can be modified with immediate feedback from the flight perspective, allowing a huge number of potential configurations to be tested in a short amount of time.

3.5 VLA Flight Setup & Evaluation Module

Some aspects of a VLA Flight Setup & Evaluation Module are demonstrated in this prototype. MS Flight Simulator provides facilities for flight setup including weather conditions as just mentioned in the previous section. The flight setup portion of the MS FS allows the user to setup initial conditions, such as the aircraft and ship to be utilized in the evaluation, the locations of each, the weather conditions and the day/night settings.

The VLA configuration portion of the flight setup is handled via VLA Modification Module save and load commands described above. So a complete flight setup facility is already provided in the Prototype.

Per the Evaluation part of the module, MS FS provides a very powerful tool right out of the box, *Instant Reply*. At anytime during a flight/approach one can use the instant replay function to see a portion or all of the flight that is being flown. The replay can be seen at different replay speeds, in addition, during the replay the view can be adjusted (e.g., change to spot plane view) so the actual view during the replay can be different during the actual flight.

A similar option is the *Flight Video* option where before starting the flight you state that a flight video should be made. These flight videos are saved to disk so they can be stored and replayed at any time and any number of videos can be made.

3.6 Movement Tracking Module

This module tracks the location of the user if the user is utilizing a movement tracking unit. There are many such movement tracking units that are compatible with MS FS so no separate processing needs to be performed. When combined with a head-mounted screen an immersive virtual reality environment can be created.

3.7 External System Interfaces (ESIs)

The ESIs, or External System Interfaces, serve as the middlemen between the different modules. The visualization module communicates with the core (integration module) and the VLA modification module via an external system interface (ESI) written in a product called FSUIPC.

3.8 Hardware

The VERTICAL Prototype software runs on today’s PCs. The system has been successfully demonstrated utilizing COTS hardware including the following configurations.

1. A 3GHz Pentium-4 processor with a 256 MB OpenGL graphics card. Under the highest reality settings the system ran at 15 frames per second.
2. A laptop with a Pentium-4 with a 64 MB OpenGL graphics card. This arrangement provides usable performance with some reality settings set to less than maximum.

3. Conclusion

The VLA Experimental Resource for Testing Innovative Configurations And Lightings (VERTICAL) provides a test and tool to support (VTOL)/rotorcraft ship VLA testing and design. With the added value of Microsoft Flight Simulator and its many low-cost add-ons and its ability to provide real world and user-set weather, this prototype allows users to fly specific aircraft shipboard approaches on a personal computer with a realistic view from the cockpit; adjust ship VLA components and environment lighting and conduct operations during day and operations and under a variety of weather conditions. The dynamic adjustment of the ship’s lights has been made possible via the use of FSUIPC and the development of an external program for controlling the lights.

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